R.N. 70269/98
ISSN : 0972-169X

Postal Registration No.: DL-SW-1/4082/09-11
Date of posting: 26-27 of advance month

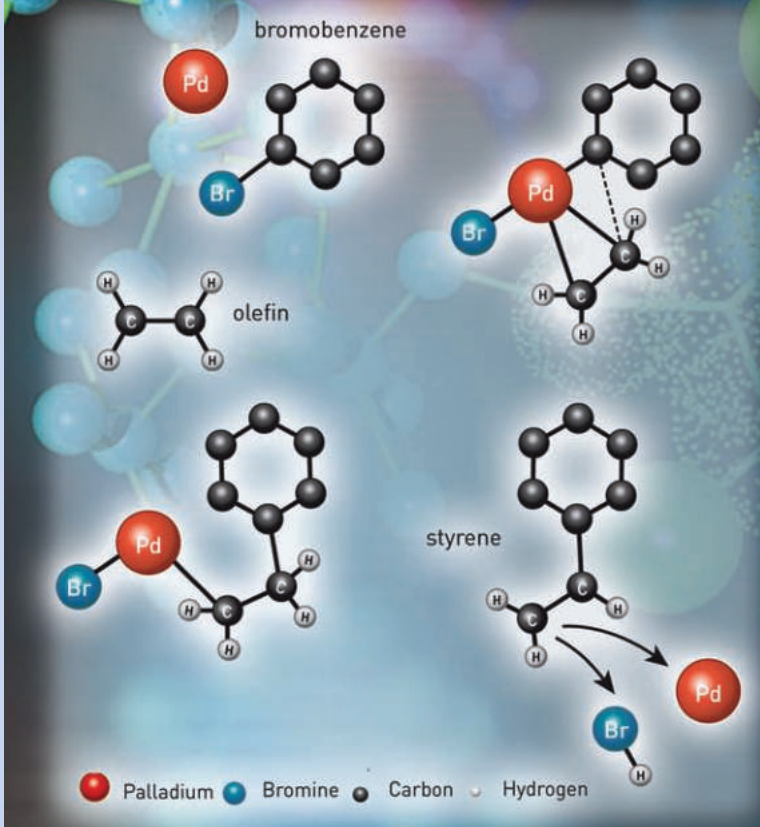
Vigyan Prasar

DREAM 2047

January 2011 Vol. 13 No. 4 Rs. 5.00

International Year of CHEMISTRY 2011

A powerful tool for organic synthesis



Paul John Flory
(Founder of modern polymer science)

(1910-1985)

Inside

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

MOVING AHEAD

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The last few months, scientists in Vigyan Prasar have displayed dynamism and flexibility in their commitment to make science and technology outreach more effective. There have been many occasions where one heard unsolicited positive feedback from scientists and planners. We cherish such comments and value criticism, however subdued and polite, even more.

Research studies have commenced to reveal impact of some major activities of the past few years and autonomy has been ensured to help identify areas of weakness and shortcomings in our efforts. Competence building is needed to pursue studies in different facets of 'Public Understanding of Science' in young researchers.

Increased interest in science programmes on radio has translated into four serials being produced and broadcast from 119 stations in 19 languages. Thirty minutes in a week is sub-critical and the footprint must increase to double the size. Can AIR and Prasar Bharati play a more active role in creating attractive programmes and broadcasting these at listener-friendly timings?

The increase in number of channels over the Indian sky is an opportunity for every communicator. The forces of commerce tend to squeeze both development and public broadcast programmes. The challenge then is to develop viewer loyalty for interesting science programmes with rich and entertaining content. The process of making video programmes, however, grapples with issues of transparency and fair play resulting in time and creativity compromises. Science news and features will shortly commence beaming on your TV sets from statutory channels and your response will help in improving the effort.

The printed word is still viewed as authoritative. Our communicators are engaged in developing a range of well-illustrated books that address concerns of the largely unreached sections of the society. The initiative attempts to help capacity building of neo-literates and will be disseminated through field workers in urban concentrations, rural settlements and tribal communities.

Communication efforts for bio-diversity conservation by Vigyan Prasar have been presented at Nagoya, Japan in the Conference of Parties recently. Training material for capacity building of village leaders is being developed by experts and will be tested shortly. This will address the felt need of zilla and gram panchayats to deliberate on development issues and opt for choices that are less damaging to bio-diversity.

Technology dissemination to rural artisans and small farmers faces several challenges. Communicators are studying successful cases to draw lessons for extension workers. The range of communication strategies – exhibitions, demonstration and training, community radio, wall newspapers and more form the subject of this initiative.

Empowering women through technology communication commenced with a high level discussion at the last Technology Day. New leads have been identified and experts have joined the efforts of scientists of Vigyan Parsar in addressing the needs of health workers, angan wadi trainers, mid-day meal worker trainers, etc.

There are over 12,000 science clubs catalysed by Vigyan Prasar in schools and communities. A range of manuals and a kit are being developed to help the activities of the clubs become more enriching for their members. The kit will have guidelines for the coordinators in improved organisation of the activities as well as more professional administration.

New activity kits, interactive CD ROMs, and many other small and big efforts are continuing to facilitate the field work of science communicators. A recent issue of DREAM 2047 included a feedback form and your response has been encouraging. You can look forward to changes in this mouthpiece of Vigyan Prasar based on your suggestions. Our web portal will soon have many additional features.

Your suggestions and inputs are important as Vigyan Prasar moves ahead.

☐ **Anuj Sinha**

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Published and Printed by Dr. Subodh Mahanti on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 and Printed at Aravali Printers & Publishers Pvt. Ltd., W-30, Okhla Industrial Area, Phase-II, New Delhi-110 020
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Paul John Flory
Founder of modern polymer science

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"It is the special properties of polymeric materials in amorphous phases that render them uniquely suited to many of the functions they perform both in biological systems and in technological applications. These properties are intimately related to the nature of the spatial configurations of the constituent molecules."

Paul J Flory in his Nobel Lecture delivered on 11 December 1974

"Flory's career was an unusual mix of industrial research, and academic activity. His research contributions have charted the course of polymer science during almost half a century. His impact has been felt not only through his published papers and books, but in his effective discussions at scientific meetings and in contributions of the many students who received their training in polymer science in his laboratory."

Harold A. Scheraga in *Resonance*, June 2003

"Flory was one of the people, who in the 1930s, began working on the properties of polymers. A particular problem at the time was that polymer molecules do not have a definite size and structure; a given polymeric material consists of a large number of macromolecules with different chain lengths. Flory approached this problem using statistical methods, obtaining expressions for the distribution of chain lengths."

A Dictionary of Scientists, Oxford University Press, 1999

Paul John Flory is known for his path-breaking and extensive contributions in the field of polymers or macromolecules. He greatly contributed to the understanding of the behaviour of polymers in solutions. Flory studied the processes by which polymers form and of their properties in bulk and in solution. He demonstrated the significance of understanding the sizes and shapes of polymers in establishing relationships between their chemical structures and their physical properties. Flory was awarded Nobel Prize in Chemistry in 1974 "for his fundamental achievements, both theoretical and experimental, in the physical chemistry of macromolecules."

Flory was a person of high integrity and honesty. He never hesitated to take up the causes of the oppressed ones. He was a modest person and never tried to exaggerate his personal achievements and also he did not like those who had high opinions about themselves. He always tried to improve the circumstances in which he happened to be. Commenting on characteristics of Flory's personality Jhonson, Stockmayer and Taube wrote: "He (Flory) was of strong, of high integrity, and his convictions on important issues ran deep and were unwavering. Because of the depth of his feelings he could be severely critical of others who did not agree with him, even on matters that according to my opinion, those of good will might reasonably hold opposing views. His convictions could run deep even on less important matters and he frequently resorted to expressing them and his disagreement with others in writing.

Paul John Flory

He wrote with passion and flair, and the resulting prose was forceful....."

Flory was born on 19 June 1910 in Sterling, Illinois, USA. His father Ezra Flory was a clergyman-educator and his mother Martha Flory (nee Brumbaugh) was a schoolteacher. Flory studied at the Elgin High School in Elgin, Illinois in 1927. His half-sister Margaret not only helped him in his early studies but also encouraged him to pursue higher studies. After completing his school education in 1931 Flory joined Manchester College in Indiana. This was the time of Great Depression and Flory had to do various jobs to support him at the College. He graduated in three years. At Manchester College he was greatly influenced by his chemistry teacher Carl W. Holl. In his autobiography written for the Nobel Foundation on the occasion of receiving Nobel Prize in 1974 Flory wrote: "My interest in science and in chemistry in particular was kindled by a remarkable teacher, Carl W. Holl, Professor of Chemistry at Manchester College, a liberal arts college in Indiana, where I graduated in 1931. With his encouragement, I entered the Graduate School of the Ohio State University where my interests turned to physical chemistry. Research for my dissertation was in the field of photochemistry and spectroscopy. It was carried out under the guidance of the late Professor Herrick L. Johnston whose boundless zeal for scientific research made a lasting impression on his students."

As stated above, inspired by his teacher Flory joined the graduate school of the Ohio State University. He dug ditches and worked in the Kelvinator factory to support himself while studying at the Ohio State University. Initially he pursued a master's programme in organic chemistry under the supervision of Cecil E. Brood. But then in the second year he opted for physical chemistry and he worked under the supervision of Herrick L. Johnston. Working in the area of photochemistry and spectroscopy Flory obtained his PhD in 1934.

After his PhD, Flory joined the DuPont Company, where he came in contact with Wallace Hume Carothers (1896-1937), an American chemist, inventor and the leader of the organic chemistry group

Wallace Hume Carothers

at DuPont, who inspired Flory to work in the area of polymers. Flory wrote: "Upon completion of my PhD in 1934, I joined the Central Research Department of the DuPont Company. There it was my good fortune to be assigned to the small group headed by Dr. Wallace H. Carothers, inventor of nylon and neoprene, and a scientist of extraordinary breadth and originality. It was through the association with him that I first became interested in exploration of the fundamentals of polymerization and polymeric substances. His conviction that polymers are valid objects of scientific inquiry proved contagious. The time was propitious, for the hypothesis that polymers are in fact covalently linked macromolecules had been established by the works of Staudinger and of Carothers only a few years earlier."

After the death of Carothers in 1937, Flory joined the Basic Science Research Group of the University of Cincinnati, where he developed a mathematical theory for the polymerisation of compounds with more than two functional groups and the theory of polymer networks or gels. After spending two years at the Cincinnati University, Flory returned to industry; first he worked at Esso (later renamed as Exxon) Laboratories (1940-43) of the Standard Oil Development Company and then at the Research Laboratory of the Goodyear Tire and Rubber Company (1943-48). During this period he was engaged in research and development of synthetic rubber, an important activity considering the fact that after the outbreak of the Second World War the supply of rubber was badly affected.

In 1948, Flory joined the Department of Chemistry of the Cornell University as George Fisher Baker Non-Resident Lecturer. Flory was invited to join the Cornell University by Peter Joseph William Debye (1884-1966), then Chairman of the Chemistry Department. It may be noted that Peter Debye, an American physical chemist, worked on dipole moment and the diffraction of X-rays in gases and he formulated Debye-Huckel theory on the behaviour of strong electrolytes. Debye was awarded Nobel Prize in 1974.

In 1957, Flory moved to Pittsburgh and joined the Mellon Institute with the objective of establishing a broad programme of basic research. However, when Flory realised that his initial objective could not be realised he left Mellon Institute and joined the Stanford University in 1961 as J. G. Jackson-C.J. Wood Professor of Chemistry.

The term "polymer" is derived from the Greek words "poly" meaning "many" and "meros" meaning "part". The term was coined by Jons Jacob Berzelius in 1833. A polymer is a very large molecule composed of repeating structural units or monomers. Because polymers are large molecules, they are also called macromolecules. The term "polymer" encompasses a large class of natural synthetic materials with a wide variety of properties. Polymers play an essential and ubiquitous role in everyday life ranging from familiar synthetic plastics (which can be moulded to form countless objects) and elastomers (having particular

Peter Joseph Debye

Jons Jacob Berzelius

kind of elasticity characteristic of rubber) to natural biopolymers essential for life such as polysaccharides, starch and cellulose, which give us food and clothing; proteins which constitute much of our body, hold it together and run it; and nucleic acids, which control heredity on the molecular level. We are increasingly becoming dependent on synthetic polymers. As Morrison Boyd write: "We wear these man-made materials, eat and drink from them, sleep between them, sit and stand on them; turn knobs, pull switches, and grasp handles made of them; with their help we hear sounds and see sights remote from us in time and space; we live in houses and move about in vehicles that are increasingly made of them."

A large number of polymers have been synthesised. This has been possible because of the unique ability of carbon to form long chain of atoms. The chemical reaction by which polymers are formed is called polymerisation. If the reaction is an addition reaction, the process is called addition polymerisation. Addition polymers are formed when unsaturated organic molecules react to form a long chain molecule; for example, the formation of polyethene (polyethylene or polythene) from ethene (ethylene).

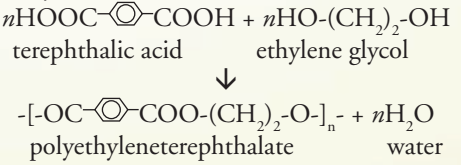
$$\underset{\text{ethene}}{nCH_2{=}CH_2} \rightarrow -- \underset{\text{polyethene}}{[-CH_2\text{-}CH_2\text{-}]n}$$

In case of addition polymerisation the double bonds are opened up to form single bonds and no small molecules or atoms are eliminated during the reaction.

Condensation polymerisation takes

Hermann Staudinger

place when bifunctional monomers react to form a long chain molecule; for example, terephthalic acid reacts with ethylene glycol to form polyethyleneterephthalate or terelyne.



In condensation polymerisation small molecules such as water are eliminated.

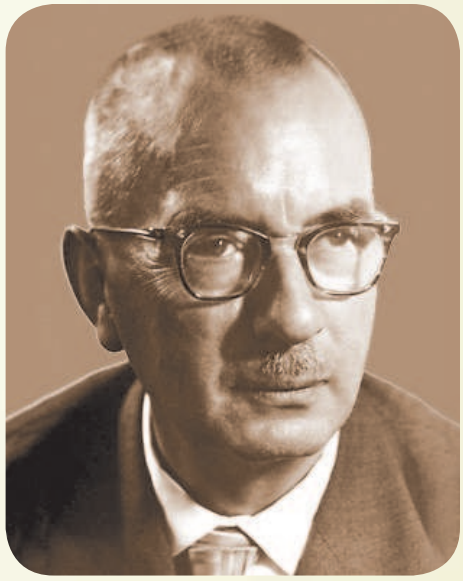
Two types of polymers can be distinguished—homopolymers and heteropolymers. Homopolymers are polymers formed from a single polymer. Typically homopolymers are formed by additions reactions involving unsaturated molecules; for example, polyethene forms from ethene. Heteropolymers, also called copolymers, are formed from two or more different monomers. Usually heteropolymers are formed by condensation reactions with the elimination of a simple molecule such as water. Polyethyleneterephthalate (PET) is an example of heteropolymer.

To appreciate the significance of the work of a scientist in a given area we must realise the background in which he worked. Before 1920s many thought polymers were clusters of small molecules (called colloids) without definite molecular weights held together by an unknown force. This was the so-called aggregate theory of polymers. It was Henri Braconnot (1780-1855), a French chemist and pharmacist, who did the earliest important work in polymer science in 1811. The development of the process of vulcanisation developed in the nineteenth century not only improved the durability of natural rubber but also led to the development of first semi-synthetic polymer. The first completely synthetic polymer Bakelite was introduced in 1909. It was created by Leo Bakeland by reacting phenol and formaldehyde at precisely controlled temperature and pressure.

In 1922, Hermann Staudinger (1881-1965), the German chemist, challenged the so-called aggregate theory. He demonstrated that polymers consisted of long chains of atoms held together by covalent bonds. For over a decade Staudinger's work was not widely accepted but it ultimately won him Nobel Prize in Chemistry in 1953. Wallace Carothers demonstrated that polymers could be synthesised rationally from their constituent monomers. The Italian chemist Giulio Natta (1903-1979) and the German chemist Karl Ziegler (1898-1973) developed the Ziegler-Natta catalyst, a special catalyst developed to produce stereospecific polymers, and derived from a transition-metal halide and a metal hydride or metal alkyl. It was an important contribution in polymer science. Natta and Ziegler were awarded the Nobel Prize in 1963.

Flory made phenomenal contributions in expanding or understanding of polymers. The impact of his contributions extends into many practical areas of everyday life. He studied the forms and properties of the polymers. Flory filled in the gaps in the existing knowledge concerning the

Giulio Natta



Karl Ziegler

forces and factors that determined the shapes of the macromolecules. Some of the important concepts developed by Flory in polymer science are: kinetics of step-growth polymerisation and of addition polymerisation, chain transfer, excluded volume, the Flory-Huggins solution theory and Flory convention

The concept of "excluded volume" was first introduced by Werner Kuhn in 1934 and in the same year it was extended to polymer molecules by Flory based on his studies of kinetics of polymerisation. In liquid state theory, the "excluded volume" of a molecule is the volume that is inaccessible to other molecules in the system as a result of the presence of the first molecule. For a hard sphere the excluded volume is eight times its volume. It is not very easy to determine excluded volume for particles with non-spherical shape. This is because the relative orientation of the particles determines the excluded volume. The excluded volume when applied to polymer science meant that one part of a long chain molecule cannot occupy space already occupied by another part of the molecule. Because of the presence of excluded volume the ends of a polymer chain in a solution tend to be away from each other compared to the ideal situation where there was no excluded volume. The introduction of the idea of excluded volume was a conceptual breakthrough. It helped to explain several puzzling experimental results of the day. This also led to the concept of theta point. According to this concept an experiment can be conducted under a

set of conditions (theta point) where the causes leading to excluded volume will be neutralised.

The Flory-Huggins solution theory is a mathematical model of the thermodynamics of polymer solutions which takes account of the great dissimilarity in molecular sizes in adapting the usual expression for the entropy of mixing.

The Flory convention was developed to define the variables involved on modelling the position vectors of atoms in macromolecules. For using the Flory convention it becomes often necessary to convert from Cartesian co-ordinates (x,y,z) to generalised coordinates, a set of coordinates used to describe the configuration of a system relative to some reference configuration.

Commenting on Flory's work, his co-worker and long-time friend Thomas G. Fox wrote: "The secret of his success is unparalleled intuition for grasping the physical essentials of a problem, for visualising a phenomenon in terms of simple models amenable to straightforward treatment and productive of results that are valid to the degree required by the original statement of the problem. Consequently Flory's concepts and results are presented in a way that is instructive, understandable and directly useful to the reader. This is equally true for those working in basic polymer science and those interested in industrial applications."

Three important works of Flory are:

1. Principles of Polymer Chemistry, Cornell University Press, 1953.
2. Statistical Mechanics of Chain Molecules, Interscience, 1969.
3. Selected Works of Paul J Flory, Stanford University Press, 1985.

Flory died on 9 September 1985 at the age of 75 in Big Sur, California.

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(The article is popular presentation of the important points of the lifeand work of Paul John Flory available in the existing literature. The idea is to inspire the younger generation to know more about Paul J. Flory. The author has given the sources consulted for writing this article. However, the sources on the Internet are numerous and so they have not been individually listed. The author is grateful to all those authors whose works have contributed to writing this article.)

International Year of Chemistry 2011

The United Nations has designated the year 2011 as the International Year of Chemistry (IYC-2011) with UNESCO as the leading UN agency together with International Union of Pure and Applied Chemistry. The focal theme of the IYC-2011 is "Chemistry—Our Life, Our Future".

The idea behind designating the year 2011 as the International Year of Chemistry is to 'celebrate the art and science of chemistry and its pivotal contributions to our knowledge, to environmental protection, to improvement of health and to economic development.' Chemistry has been rightly called the central science, which has linked the familiar with the fundamental. Chemistry is the scientific study of the composition and properties of matter. Thus the understanding of the material nature of our world is grounded in our knowledge of chemistry. All living processes are controlled by chemical reactions.

Through different activities at different levels—local, regional, national, and international – IYC-2011 will try to achieve the following:

i. Improvement of the understanding and appreciation of chemistry by the public.
ii. Enhancement in international cooperation by serving as a focal point or information source for activities by national chemical societies, educational institutions, industry, governmental and non-governmental organisations.
iii. Promotion of the role of chemistry in contributing to solutions to global challenges.
iv. Building capacity by engaging young people with scientific disciplines, especially the scientific method of analysis developed by hypothesis, experiment, analysis and conclusions.
v. Generation of enthusiasm for the creative future of chemistry.

The year 2011 marks the one-hundredth anniversary of the Nobel Prize in Chemistry awarded to Marie Curie in 1911. This was Marie Curie's second Nobel Prize; she was earlier awarded the Nobel Prize in Physics in 1903. IYC-2011 will provide an opportunity to focus on the achievements of women scientists, as Curie's achievements continue to inspire students, particularly women, to pursue a career in science.

The year 2011 also marks the one-hundredth anniversary of the establishment of the International Association of Chemical Societies in Paris (which later became the International Union of Pure and Applied Chemistry or IUPAC). So the IYC-2011 will also help highlight the importance of international cooperation in the development of chemistry.

Vigyan Prasar will work in collaboration with other organisations including schools, colleges, government agencies and NGOs for creating awareness about the importance of chemistry in meeting our present needs and ensuring well-being of future generations. It will try to highlight the major achievements of chemistry in recent years both in India and abroad. Through various activities Vigyan Prasar will attempt to draw the attention of first-rate students to chemistry. It will try to help the public to appreciate the importance of chemistry in their daily lives.

Subodh Mahanti ■

Vigyan Prasar has planned to organise nation-wide activities during IYC-2011

It may be noted that Vigyan Prasar organised nation-wide activities during the International Year of Physics-2005, International Year of Planet Earth 2008, and International Year of Astronomy 2009. VP has also planned a number of activities during the International Year of Biodiversity 2010. The proposed activities for the IYC-2011 are the following:

1. Innovative experiments in chemistry.
2. Audio programme.
3. Television programme.
4. Interactive activity kit.
5. Training of resource persons for conducting programmes in schools .
6. Wall planner.
7. Fun with chemistry.
8. Preparation of specific materials for agricultural workers.
9. Preparation of specific materials for women self-help groups.
10. Hands-on demonstrations.
11. A set of posters on chemistry and healthcare.
12. Food adulteration kit.
13. Resource materials on kitchen.
14. A CD on power-point presentations on different aspects of chemistry.
15. Innovative multi-media presentations on chemistry.
16. Specific activities/programmes for popularising the life and work of Acharya P.C. Ray.
17. Books : Pioneers of Modern Chemistry; The World of Chemical Elements; Chemistry and Human Life; Chemistry in the Kitchen; What is Chemistry?; A Quiz Book in Chemistry; Success Stories in Indian Chemistry; Careers in Chemistry; The Story of Oxygen; Fingerprints of Elements; and books linking major issues like climate change with chemistry and highlighting the contributions made by the Nobel Laureates 1901-2009. Reprints of the following two books The Story of Chemistry and Topsy-turvy in Chemistry will be brought out. Some new titles are in the process of being identified.
18. Posters—A set of posters depicting the growth of chemistry and how it has influenced human life.
19. Popular lectures in different parts of the country by well-known chemists and science communicators.
20. Green chemistry.
21. Workshops/training programmes.
22. Articles in newspapers/magazines.
23. Entrepreneurial activities like soap making.
24. Chemistry behind "Miracles".
25. Desk calendar.

A powerful tool for organic synthesis

Biman Basu
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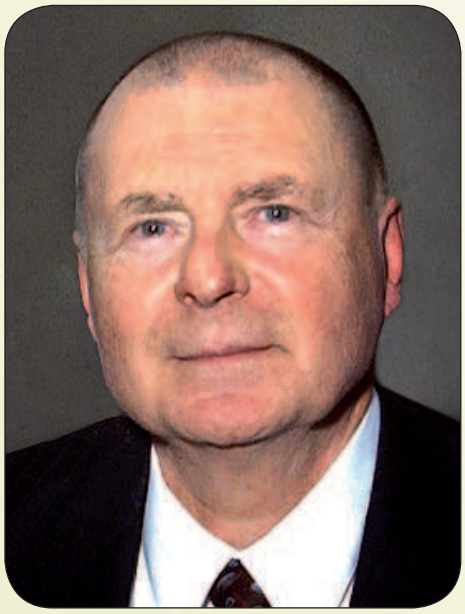
Organic chemistry is the basis of life and is responsible for numerous fascinating natural phenomena we see around: colour and fragrance of flowers, sweetness and flavour of fruits, snake poison, and also bacteria killing substances such as penicillin. Organic chemistry has allowed scientists to build on nature's chemistry – making use of carbon's ability to provide a stable skeleton for functional molecules. This has given mankind new medicines to fight disease and revolutionary materials such as plastics and polymers to make life better.



Richard F. Heck

All chemical reactions involve rearrangement of atoms, which in turn involve breaking some bonds and making new bonds. Carbon-carbon bonds can be broken easily, but in order to create complex chemicals, chemists need to be able to join carbon atoms together. Chemists did develop some methods to join carbon atoms together, which worked when creating simple molecules. In fact, efficiently forming carbon-to-carbon bonds has long been a focus of chemistry, and various methods – starting with Victor Grignard's use of magnesium to help bind carbon atoms in 1912 – have been awarded the chemistry Nobel. But when trying to synthesise more complex molecules, they ended up with too many unwanted by-products in their test tubes.

In course of time, reactions using the relatively rare silvery-white metal palladium as catalyst solved that problem and provided chemists with a more precise and efficient tool to work with. The technique enabled the building of complex organic compounds with wide application in medicine, industry and agriculture. In the so-called palladium-catalysed cross coupling reactions, developed independently by Richard F. Heck , Ei-ichi Negishi, and Akira Suzuki, carbon atoms are made to come together on a palladium atom, whereupon their proximity to one another kick-starts the chemical reaction. The three scientists have been awarded the Nobel Prize in Chemistry for 2010 for their work. Heck (79) is a professor emeritus at the University of Delaware, now living in the Philippines; Negishi (75) is a chemistry professor at Purdue University in West Lafayette, USA; and 80-year-old Suzuki is a retired professor from Hokkaido University in Sapporo, Japan.

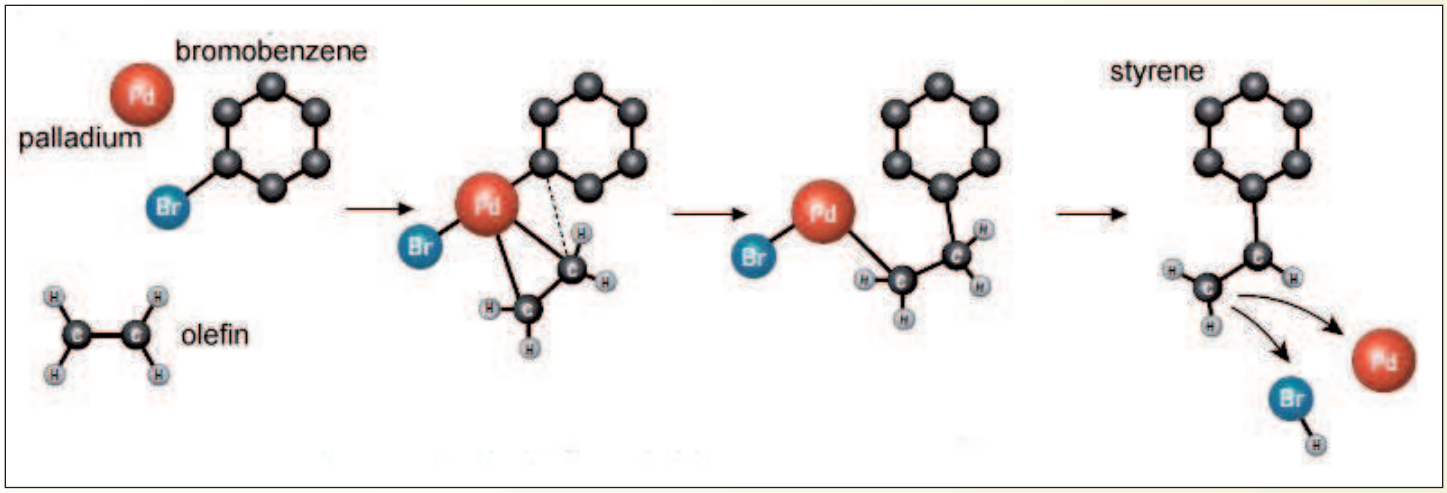
The palladium-catalysed cross-coupling reaction is unique since it is possible to carry it out under mild conditions and with very high precision. Previously, chemists had to use reactive substances and high temperatures to start the chemical reaction to join two carbon atoms. But as mentioned earlier, such methods led to the creation of unwanted by-products. When chemists want to create large molecules they build up the molecule in several steps. Production of too much unwanted by-products in each step, often left too little material to work with.

Ei-chi Negishi

Akira Suzuki

For joining carbon atoms, chemists need to first activate the carbon atoms and make them more inclined to react with another carbon atom. Victor Grignard, Nobel Laureate in Chemistry in 1912, found a solution to this problem. Using various chemical tricks he coupled a magnesium atom to a carbon atom that he wanted to make more reactive.

The Grignard reaction, which uses a carbon-magnesium compound, is one of the characteristic reactions especially useful as a means of forming new carbon-carbon bonds. The Grignard method of coupling carbon atoms has been enormously important in chemistry. But when it comes to creating large and complex molecules, the method has its limitations. The carbon atom in the



The Heck reaction. Richard Heck experimented with palladium as a catalyst and linked a short olefin to a ring of carbon atoms. When the two meet on the palladium atom they react with each other, producing styrene – a fundamental component of plastics. (Credit: nobelprize.org)

unstable Grignard reagent does not behave predictably. When the reagent has several different carbon atoms to react with, too many unwanted by-products are created. The palladium-catalysed cross-coupling reaction solves this problem and provides precision in the process.

When palladium is used as a catalyst, it provides a setting that allows carbon atoms or compounds with carbon in them to come together for bonding, acting like a matchmaker. Once close enough, the carbons form their own attachment and drop the palladium, enabling the catalyst to produce more such pairings. Thus palladium takes part in and facilitates the process, but is not itself consumed.

Palladium-catalysed cross coupling is used in research worldwide, as well as in the commercial production of pharmaceuticals and molecules used in the electronics industry. The materials that can be produced using palladium-catalysed reactions range from carbon-based polymers such as styrene used to make plastics to organic compounds that can emit light, enabling thin television screens or computer monitors. However, the processes find their widest application in synthesising medicinal compounds, especially anti-cancer drugs.

In fact, one of the most notable applications of the palladium-catalysed cross-coupling reaction was for the synthesis of the anti-cancer compounds called 'discodermolide', which was first discovered in the marine sponge Discodermia dissoluta in the Caribbean Sea. In the marine sponge discodermolide is found only in minute quantities, and the natural source would have never been enough to meet the demand for its medicinal use. Using the palladium-catalysed cross-coupling reaction, scientists can now artificially produce discodermolide. Negishi's variant of the reaction was used as a central step in its synthesis. Other scientists have subsequently optimised the process and managed to obtain sufficient quantities of discodermolide to begin clinical testing on humans suffering from cancer.

Richard Heck was working for an American chemical company in Delaware, when he began experimenting with using palladium as a catalyst. In 1968 he published his successful work in a series of scientific papers including one describing addition of methyl and phenylpalladium halides to olefins at room temperature. A further step allowed the unprecedented alkylation of an olefin. Among other things, he was able to link a ring of carbon atoms to a shorter fragment of carbon in order to obtain styrene, a major component in the plastic polystyrene. Four years later he had further developed his reaction which has come to be known as the 'Heck reaction' and is one of the most important reactions for creating single bonds between carbon atoms. For instance, it is used in large-scale production of the anti-inflammatory drug Naproxen, the asthma drug Montelukast, and to produce a substance used in the electronics industry.

In 1977, Ei-ichi Negishi developed a variant of the Grignard reagent when he substituted magnesium for zinc. He investigated the palladium-catalysed cross-coupling of organometallic species with organohalides, eventually demonstrating that organozinc compounds could permit highly selective reactions under mild conditions and in the presence of a range of functional groups. The carbon atom becomes less reactive when using zinc, but the zinc atom transfers the carbon atom to the palladium atom. When the carbon atom subsequently meets another carbon atom on the palladium atom, then they can easily bond.

Two years later, Akira Suzuki used the element boron. It is the mildest activator so far and is even less toxic than zinc, which is an advantage when it comes to large-scale applications. For instance, Suzuki's reaction is used in the commercial synthesis of a substance that protects agricultural crops from fungi.

In subsequent years these reactions were improved and modified to become indispensible tools for the organic chemist and have been used to synthesise a range of complex natural products which would otherwise remain extremely difficult if not impossible to make. For example, the methods developed by the three scientists have been used to create new antibiotics that work on resistant bacteria and a number of commercially available drugs, including the anti-inflammatory drugs.

Today, it is estimated that no less than 25 percent of all chemical reactions in the pharmaceutical industry are based on these methods. Palladium-catalysed cross coupling has also been used by the electronics industry to make light-emitting diodes used in the production of extremely thin monitors. ■

Leader of appropriate technology
D. Raghunandan

The Centre for Technology & Development, or CTD, as it is popularly known, is a unit of the Society for Economic & Social Studies (SESS) and is an independent non-profit organisation working in the field of sustainable rural development through science and technology applications.

The formation of CTD with several field stations in Dehradun (UA), Mandi (HP), Ukhrul (Manipur) and Kavali (AP) was catalysed by the Delhi Science Forum, a reputed public-interest organisation focusing on S&T policy issues, with the goal of putting forward and demonstrating alternative models for sustainable development.

CTD/SESS is a multi-disciplinary group of dedicated and experienced professionals with backgrounds in engineering, natural sciences, medicine, social sciences, etc. D Raghunandan is a key person behind the success of CTD who has been leading CDT during the last 27 years. Er Anuj Sinha, Director, Vigyan Prasar and Consultant, Department of Science & Technology, Govt. of India interacted with D. Ragunandan on the role of S&T in social entrepreneurship, problems of rural artisans, new technological solutions, and related issues. Here are excerpts from the interview.

Anuj Sinha: Raghunandanji, please introduce yourself and your work for our readers.

D. Raghunanadan: My basic degree is a Bachelor's in Mechanical Engineering (Hons.) with specialisation in aero-engines. I obtained my degree from London University in 1971 and was sponsored for my studies by M/S Rolls Royce Aero Engines Ltd, UK with whom I served as an engineering apprentice. I then worked for a few years at Hindustan Aeronautics Ltd, Aero-Engines Design Division, Bengaluru. My life then took a strange turn when, for a variety of reasons, I decided to pursue further studies in the Social Sciences. I obtained an M.Phil in Sociology from the Jawaharlal Nehru University, New Delhi and also did research work towards a doctorate. After university, I was invited by the Delhi Science Forum, a Delhi-based NGO working in the area of science and technology policy, to lead a project sponsored by the Department of Science & Technology (DST) to conduct field and other studies in collaboration with a coalition of S&T-based NGOs and S&T Institutions towards working out a direction and approach for application of S&T for rural development. Recommendations of this sponsored project were then utilised to lay

D. Raghunandan

the foundation for the societal programmes of DST. This project also catalysed a new organization, the Centre for Technology and Development (CTD), New Delhi, which I have been leading for the past 27 years and which has been engaged in development and dissemination of appropriate technologies for rural industrialisation.

A S: Raghunandanji, you have a remarkable career graph. You obviously bring the precision of engineering and the horizons of sociology to your work. Could you have the same job satisfaction if you had opted for a regular career in the industrial sector or the academic world?

D R: Yes I probably could, both in industry and academics, as so many of my contemporaries do. But I do feel that my work in the NGO sector and with CTD in particular, has given me enormous satisfaction which I may not have got in a different career. I am my own boss and decide my own projects according to my chosen areas of interest. My work combines in a fantastic way both the disciplines I love, namely engineering and sociology, and I feel uniquely enabled to conduct multi-disciplinary action research with both academic and social impact. And finally, it is both hugely challenging and enormously satisfying to know that I am contributing to the welfare of the underprivileged sections of my country and to the creation of models for social transformation.

A S: This is very encouraging. I do not meet many others who can feel really satisfied with their career choices. Often, they regret the decisions made. What really influenced your moves? Did your parents have a major role? Did you have a role model then?

D R: These are very interesting and serious questions, and I hope I can do justice. Part of my motivation in the early years was that most work done assigned to engineers, at least at that time, was of a managerial nature and, even if the work was technical, the scope for creativity was rather narrow. This may be an erroneous perception or restricted only to certain sectors of industry in the early seventies, but nevertheless that was how I experienced it and that was a major motivating factor. On the other hand, my interest in sociology was genuine and kept growing till it became irresistible! My readings also showed me that several renowned scholars had made a successful transition like I was contemplating. Famous sociologist Malinowski, philosopher Wittgenstein and in more modern times Edmund Leach in the UK, Jit Singh Oberoi in Delhi University, Sudhir Kakar the psychoanalyst in Delhi were all inspirations. I was doubly fortunate in that I did not abandon engineering but am able to combine both my disciplinary interests in the work that I do. There were three big influences in my career. The first was my University, JNU, which showed the courage to admit me into the MPhil/PhD programme while all other universities wanted me to do an MA. And as should happen in the best universities, I learned as much outside the classroom, from intense interactions with students and faculty, as I learned inside it! The second huge influence was my mother, a career educationist herself, who gave me full support in making this transition which was a very big risk indeed. Finally, DST and especially its Science

& Society Division (now called SEED Division) has been like an anchor, allowing this creativity to flourish and providing the much-needed financial support. The open-minded, liberal and creative atmosphere at DST, quite non-typical in India, has been of enormous help.

A S: I recall our interaction at Wardha about 25 years back when we were both studying the problems of rural artisans from different perspectives – you from the field and I from the sponsoring organisation. Your perceptions over the past three decades must have transformed in light of continued intensive interaction with the society. What have been the major changes in the rural areas? How have artisans have survived these changes?

D R: I feel that in many ways villages particularly in northern India have not changed much although rural areas taken more broadly including small towns have changed considerably. Perhaps the biggest change is visible in district towns where consumer goods, white goods, brand name stores, etc., are widespread compared to two decades ago when every third shop sold vessels, textiles or groceries, with a few jewellery stores and eateries thrown in. In part, this reflects the growing prosperity of a section of the rural populace. Rural people though have changed in deeper ways. Their knowledge of developments in other parts of the country, in cities and in industry, is far greater than it once was. Rural people are more aware; they feel they have potential to bring about changes and are politically more awakened. But opportunities to actually change are scarce, migration to cities remains an option but with not very good prospects in the face of "jobless growth". Also, mainstream thinking and institutional frameworks have not changed in ways that could respond to the new aspirations of rural India. As far as artisans and other working people in rural areas go, they are barely surviving, their prospects and opportunities have shrunk substantially, and agriculture, which is the base of the rural economy, is stagnant if not declining. The future for rural areas lies in rural industrialisation which is the best option for employment generation as well as for transformation of the rural economy.

A S: CTD has been leading the appropriate technology driver in the country. The organisation has constantly reviewed its strategies and priorities to address issues of importance. Many other such groups have not been able to display such dynamism. What has been the key to this success? Is size of an organisation important? How are you attracting fresh talent to keep the group relevant to its mandate?

D R: Again, challenging questions! I think part of CTD's success lies in carefully and systematically approaching technology development options sector-by-sector after a thorough study of the sector, the foreseeable scenario in technology and markets, and available technologies and the state of art, along with participatory identification of felt needs and problems of target groups and those of all other stakeholders in the production and distribution chain of goods, services and knowledge. CTD has consistently avoided a top-down approach of evolving some technology which WE think is best and then figuring out why it is not being absorbed by its intended users. Our multi-disciplinary approach has helped. So has a clear vision that economic viability and self-sustainability is our goal. No, I don't think size of an organisation is important, but the culture of creativity built and promoted

About CTD/SESS

The Society for Economic & Social Studies (SESS) is an independent non-profit organisation working through its executive arm, the Centre for Technology & Development (CTD).

CTD/SESS works towards sustainable development and rural industrialisation for the benefit of artisans, small farmers, landless labour and other deprived sections especially women through S&T-based innovation and participatory action research.

Major thrust of CTD/SESS is on development and dissemination of viable technology packages and replicable models for pro-poor rural enterprises in different sectors (spanning the entire innovation chain comprising technology generation, production, capacity-building and organisation), and on policy advocacy, campaigns and community-level interventions in public health. With the above focus CTD/SESS:

- provides turnkey and other consultancy services to user groups and development agencies covering feasibility studies, project design, project commissioning and management, training, trouble-shooting and hand-holding towards sustainability;
- undertakes applied social science research, studies/surveys, monitoring/evaluation;
- engages in nationwide action programmes, campaigns and advocacy in public health;
- works throughout India on its own and/or in partnership with a wide network of NGOs;
- itself runs production and other activities at its Field Station in Dehradun district of Uttaranchal;and
- has collaborative linkages with several S&T Institutions.

CTD/SESS has been active since 1982 and:

- is a multi-disciplinary group of dedicated and experienced professionals with backgrounds in engineering, natural sciences, medicine and social sciences;
- has core competences in systems-based appropriate technologies for rural industries, public health, participatory action research and social research;
- is widely acknowledged as a leading agency in the field of rural industrialisation;
- has evolved replicable technologies and field models in several non-farm sectors of vital importance to the rural and national economy;
- has helped set up and run over 200 rural enterprises in 26 States/UTs;
- fabricates and supplies innovative equipment/machinery for different rural industries;
- manufactures and markets a wide variety of processed fruit and vegetable products under the brand name 'FARMERS' which is also franchised currently in six areas;
- has implemented numerous projects supported by governmental agencies at national or state levels and international agencies of the UN system.

within the organisation is. Sometimes smaller more compact organisations deliver better results. Attracting fresh young talent has been the biggest challenge and I cannot claim much success in this. Perhaps these things have a generational cycle. My generation was shaped in the idealistic sixties and seventies, and perhaps more of us are driven to dedicate ourselves to societal causes than at present when the youth are more driven by career prospects and financial goals. Such a trend was witnessed in the West too where, however, the next trend-change has already begun. Maybe we have to wait for the next wave in India a decade or two down the road!

A S: Your focus on rural development has yielded many interesting models of income generation that have become sustainable. What are the issues in wide scale replication of such models? How can CTD help in these being adopted by main stream development or financing agencies?

D R: I would characterise institutional reform as the biggest challenge in widespread adoption of rural enterprise models, and by "institutional reform" I mean changes in the way all of us, NGOs, government, banks and others, do things. Technology developers must take responsibility for dissemination also and not leave the job to others, and this also implies that more attention needs to be paid to the viability and suitability of the technology for uptake. NGOs need to professionalise, to move from being do-good charities to groups with specialised competences and an entrepreneurial spirit. The very concept of rural enterprises in developmental circles needs to undergo fundamental changes. The "cobbler under the tree" model of tiny household-based activities is no longer relevant, high quality and productivity are essential in contemporary markets and this is where good, high-class yet appropriate technology comes in. Collectively it is necessary that not just technologies but also enterprise models be evolved and mainstreamed so that financing for such enterprises is available through normal banking channels which require to be sensitised and enabled to make the necessary changes in their systems and thinking.

A S: You can be classified as a social entrepreneur. How can we breed more such entrepreneurs?

D R: To some extent I believe entrepreneurs are born, one cannot teach someone to have an entrepreneurial spirit or drive, he or she either has it or not! Dhirubhai Ambani was not well educated, neither is Bill Gates of Microsoft! An MBA degree holder may make a great manager but may not succeed as a businessman. In fact I believe statistics show that very few MBA graduates become entrepreneurs. At the same time, it is important to recognise the entrepreneurial spirit in some one, then encourage it, cultivate it and refine it. At a broader societal level, it is necessary to promote entrepreneurship and provide more encouragement to entrepreneurship, self-employment and a sense of enterprise among the youth especially in the urban middle-classes from communities without a traditional trade or business background. Regulatory systems also need to be reformed so that it becomes easier for people to start and run small businesses without the notorious red tape, procedural hassles, multiple clearances, huge paperwork and corruption that make India one of the lowest ranked countries in the world in terms of ease of doing business. So these are larger societal-level challenges rather than just individual ones.

D. Raghunandan with Er Anuj Sinha

A S: The urban poor are in many ways worse off than their rural counterparts. Will they be the focus of CTD and how?

D R: At present we have our hands full with rural transformation. Not that we have neglected urban employment issues. We have initiated urban enterprises in patch-work leather bags and other goods using waste from the leather garment industry, and have also undertaken research on laundry systems for dhobis, introduced LPG-fired kilns for urban potters, new-design cycle rickshaws and so on. The problems in urban areas are quite different and the challenges lie even more in legal, regulatory and sociological aspects than in technological terms. Nevertheless, CTD is also turning its attention to some potential urban-poor enterprises such as machine-made incense sticks, recycled paper and products, and other such areas which build upon materials and resources characteristic of urban areas.

A S: You mentioned about prioritisation of problems. Can we have a system of identifying and classifying a range of problems that can be given as challenges to R&D or educational institutions?

D R: Yes this is possible, and such attempts have been made earlier too. It is necessary, however, that R&D or educational institutions be geared to meet such challenges. It is a common misunderstanding that any scientist and technologist can tackle and solve rural problems. In fact, these require reorientation and a commitment by scientists and technologists to a different way of thinking and working, as well as efforts to understand rural needs. "Intermediate organisations" such as NGOs have a crucial role to play. They can 'translate' felt needs into S&T problems that R&D Institutions can more easily take up, and also help these R&D or educational institutions in outreach for which they are not geared.

A S: What type of technological support services are possible for artisanal groups to sustain their economic activities based on new technological solutions developed by CTD or other such groups? Is there a case for trained force of diploma holding engineers to support such efforts?

D R: Handholding and support services are perhaps the most important, and regrettably the most neglected, aspect of technology dissemination or transfer. This is also one of the reasons why R&D Institutions

face difficulties in this field, because such institutions are simply not structured to perform such functions and scientists who work in them do not have the time to do so. NGOs are better placed but need to re-orient themselves and acquire the technical capability to offer such services. Diploma engineers or other "barefoot technicians" are well equipped to play such roles provided they have a supportive institutional framework to do so, such as from within S&T NGOs or other R&D Institution engaged in S&T-based rural development.

A S: For many years CTD documented efforts of pioneering groups and disseminated it among interested institutions. Is there a need for reviving such a vehicle? What shape should it take?

D R: There is a sore need for regular dissemination of information on appropriate technologies for both rural and urban application. At present there is no single-point source of reliable information and potential users of appropriate technologies are forced to rely on word of mouth, a few stray in-house publications and some compendia brought out by different agencies which list thousands of technologies but give little or no information as to their success in the field, viability or other such practical and essential information. Need-based Information systems should be available in both print form and on the internet so as to maximise access while also enabling continuous updating. There is another important need such a vehicle should cater to. There are today many researchers in S&T NGOs, S&T institutions and academic institutions working in the field of appropriate technology which is a specialised discipline although unfortunately not recognised as such. But unlike other disciplines, there is no journal which can be used as reference or where research findings can be perused. So a vehicle such as being discussed here should also try to capture and communicate information on on-going research and their status so that unnecessary duplication is obviated, experiences can be shared and new researchers can properly identify a subject of research and chart a direction for it.

A S: Women need to be the focus of developmental efforts to raise a community above poverty. You have helped in many policy initiatives in this area. What are your views on this and how can more such efforts be nurtured?

D R: Women are crucial to the future of the nation. It is imperative that more women in both urban and rural areas are brought into the work force with technical skills and knowledge so as to enable India to emerge into the modern industrial and "post-industrial age". One of the important things I have learned is that women should be encouraged and enabled to leave the home for work to the extent possible. Why should women be perennially bound to housework? It is too often assumed that women will (and must?) stay at home, so work is designed for them to do in their "spare" time. But precisely because their time is undervalued, such tasks, for example put-out labour like envelope-making or agarbatti-rolling, end up being drudgery-filled and do not even compensate for the time spent. Other forms of indirect exploitation of women include "family labour" such as in pottery. Our experience of running FPO-licensed fruit processing enterprises with mostly women workers is that women find it a highly liberating experience to work in a factory-like environment away from home, socialising with a variety of others, being exposed to many experiences and broadening their horizons besides generating substantial incomes for them and enhancing their social status.

A S: It has been a very enriching experience talking to you. Thank you for sharing your views and ideas with our readers. ■

Letters to the editor

Useful for students

Just now I got this esteemed magazine from my friend. I am impressed by the excellent article on Justus Von Liebig. I have had the privilege of visiting his lab (Liebig University, Germany) during my stay in Germany. Similarly, the information about the Nobel laureates is very good. I would like to receive the magazine regularly. It will be useful for my students.

Dr. Prof. V.D.Patil,
Head, Department of Agriculture, Chemistry and Soil Science,
Marathwada Agricultural University,
Parbhani, Maharashtra 431402

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Thank you

Thank you so much for the copies of Dream 2047, where our views have been thoroughly and accurately covered. I thank your office for doing such a nice job. Let us hope to have more collaboration between Vigyan Prasar and JBNSTS.

Papiya Nandy
Director, JBNSTS

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Magic Mantras to Prevent and Heal the Ulcers in Stomach and Duodenum

Dr Yatish Agarwal
e-mail: dryatish@yahoo.com

Too much "chaat-pakori", a tad too much of spices in the food, or too much stress, and not just your Mom and Dad, but your doctor was also quick to warn you that you could be headed for an ulcer.

Until just a few years ago, the common belief was that ulcers were a result of lifestyle. But not any more. Doctors now know that a bacterial infection or medication, not stress or diet, causes most ulcers. The big welcome tidings are: instead of taking months or years to treat, ulcers can often be cured in 2 to 4 weeks.

Types of peptic ulcers

Ulcer is the medical term for an open sore. Peptic ulcers develop on the inside lining of the stomach or small intestine. The lining of the stomach and the duodenum normally has a barrier of mucus to protect it from the effects of acidic digestive juices. If the barrier is damaged, the acid may cause inflammation and erosion of the lining. The resulting eroded areas are known as peptic ulcers.

There are two types of peptic ulcers. A peptic ulcer that occurs in the stomach is called a gastric ulcer. If the ulcer develops in the small intestine, it commonly develops in the first part of the small intestine. This section of the small intestine is called the duodenum, and an ulcer that develops in this part is named a duodenal ulcer.

Duodenal ulcers are more common than gastric ulcers and usually occur in people aged 20 to 45, particularly men. Gastric ulcers are more common in people over the age of 50.

Causes

Bacteria are the culprits

The understanding and treatment of peptic ulcers has changed in a big way since 1983 when two Australian researchers found a corkscrew-shaped bacterial organism in biopsy specimens of people who had ulcers and persistent stomach inflammation (gastritis).

The bacterium discovered by the researchers, called Helicobacter pylori *(H. pylori),* lives and multiplies within the mucous layer that covers and protects tissues that line the stomach and small intestine. Often, *H. pylori* causes no problems. However, sometimes it can erode digestive tissues, producing an ulcer.

Approximately 1 in 20 people infected with *H. pylori* get an ulcer. One reason may be that these people already have damage to the lining of the stomach or small intestine, making it easier for bacteria to invade and infect tissues.

The risk of harbouring *H. pylori* bacteria increases with age. By the time they are in their 20s, a large majority of people in this country are infected with *H. pylori*. Although it is not clear how the organism spreads, it appears to be transmitted from person to person by close contact. Poor food handling and sanitation practices are thought to be common routes of transmission. As scientists have found *H. pylori* in water, they suspect the infection also may be transmitted in contaminated drinking water.

Other risk factors include:

- Having a low socio-economic standard of living
- Living in a large family or crowded conditions
- Having an infant in the home
- Being exposed to vomit of an infected individual

Such a situation may arise even in well-to-do families, due to the lack of hygiene on part of the cook or the domestic help who works for them.

This new understanding into the causation of ulcers has been truly a major breakthrough. In countries that have developed higher standards of sanitation, and have understood the significance of hygiene, have a much lower rate of new *H. pylori* infections, and lower incidence of peptic ulcers.

Helicobacter pylori presently accounts for 50 per cent or more of all peptic ulcers. In certain populations, such as smaller cities with crowded conditions and a low socio-economic standard of living, the rate of *H. pylori* infection is much higher than in other parts.

Beyond "the bug"

Helicobacter pylori is the most common. However, it is not the only cause of peptic ulcers. The other causes of peptic ulcers include:

Excessive use of pain relievers

Non-steroidal anti-inflammatory drugs (NSAIDs) like aspirin, ibuprofen, naproxen and ketoprofen can irritate or inflame the lining of your stomach and small intestine. The medications are available both by

prescription and over the counter. To help avoid stomach upset, take NSAIDs with meals.

About 20 per cent of people who take NSAIDs regularly develop ulcers. The drugs inhibit production of an enzyme (cyclo-oxygenase) that produces prostaglandins. These hormone-like substances help protect your stomach lining from chemical and physical injury. Without this protection, stomach acid can erode the lining, causing bleeding and ulcers.

It is possible that regular use of NSAIDs also may increase risk of ulcers in people infected with *H. pylori*.

Smoking

Nicotine in tobacco increases the volume and concentration of stomach acid, increasing your risk of an ulcer. Smoking also may slow healing during ulcer treatment.

Excessive alcohol

Alcohol can irritate and erode the mucous lining of your stomach and intestines, causing inflammation and bleeding. It is uncertain, however, whether this alone can progress into an ulcer or whether other contributing factors must be present, such as *H. pylori* bacteria or nicotine.

Role of psychological stress

Psychological stress is no longer believed to be one of the primary causes of peptic ulcers, but it may play a part in making an existing ulcer worse.

Common symptoms

The most common symptom of a peptic ulcer is a gnawing pain in the upper abdomen between the bellybutton and breastbone. This pain, caused by stomach acid washing over the open sore, may linger for just a few minutes, or it may last for hours.

The pain from a duodenal ulcer is often worse before meals when the stomach is empty, and therefore tends to flare at night. Food buffers the acid. That is why eating often temporarily relieves the pain. But it usually recurs a few hours afterwards.

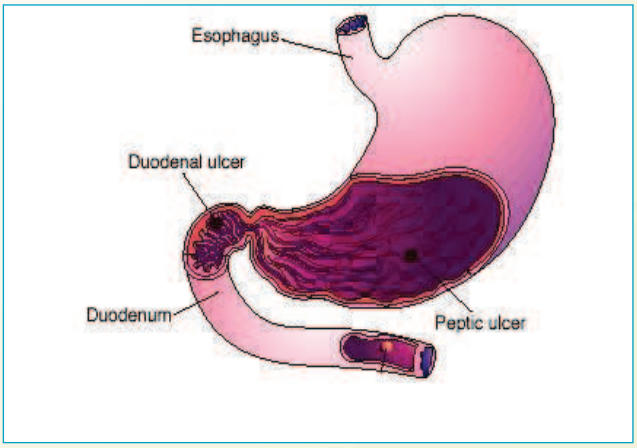
By contrast, pain caused by a gastric ulcer is often aggravated by food. Quite understandably, more than a few people suffer loss of appetite, and therefore, lose weight.

Some people experience feeling of fullness, nausea and sometimes vomiting. Other signs and symptoms include vomiting up blood, which may appear bright red or black, and blood mixed with stool that may appear dark-coloured.

Complications

Left untreated, peptic ulcers can cause internal bleeding. This happens when the ulcer becomes deeper and erodes into the nearby blood vessels.

Minor bleeding may cause no symptoms apart from those of iron deficiency anaemia, such as pale skin, tiredness, and faintness. It may also result in vomiting of blood. Alternatively, blood may pass through the digestive tract, resulting in black, tarry stools. Sometimes the bleeding can become so severe as to be life threatening and may require urgent medical attention.



In some people, an ulcer can "eat" a hole through the wall of the stomach or small intestine, allowing gastric juices to enter the abdomen and putting you at risk of serious inflammation of your abdominal cavity (peritonitis).

Occasionally, gastric (stomach) ulcers also can produce scar tissue and result in narrowing of the stomach outlet into the duodenum, which prevents the stomach from emptying fully. When that happens, a person may feel bloating after meals, vomit undigested food hours after eating, and suffer weight loss.

Diagnosing an ulcer

If your doctor suspects that you have an ulcer, he or she may arrange an endoscopy to view the stomach and duodenum. In this sensitive procedure, a long, narrow tube with an attached camera is threaded down your throat into your stomach and duodenum. With this instrument, your doctor can view your upper digestive tract and identify an ulcer.

If an ulcer is found, your doctor may remove small tissue samples (biopsy) near the ulcer. These samples are examined under a microscope to rule out cancer of the stomach. A biopsy also can identify the presence of *H. pylori* in your stomach lining. Since cancer of the duodenum is rare, a biopsy of a duodenal ulcer is seldom necessary.

In addition to a biopsy, three other tests can determine if the cause of your ulcer is H. pylori infection:

Blood test

It checks for the presence of *H. pylori* antibodies. A disadvantage of this test is that it cannnot differentiate between past exposure and current infection. After *H. pylori* bacteria have been eradicated, you may still get a positive result.

Breath test

This test uses a radioactive carbon atom to detect *H. pylori*. First, you blow into a small plastic bag, which is then sealed. Then you drink a small glass of a clear, tasteless liquid. The liquid contains radioactive carbon as part of a substance (urea) that will be broken down by *H. pylori*. Thirty minutes later you blow into a second bag which also is sealed. If you are infected with *H. pylori*, your second breath sample will contain the radioactive carbon in the form of carbon dioxide. It takes about a day to get the test results.

If you are taking a medication called a proton pump inhibitor, it is important that you stop taking the medication for at least three days before the breath test, because the medication can interfere with the test results.

The breath test is sensitive to the presence of *H. pylori* nearly 90 per cent of the time. That is similar to the blood test. The advantage of the breath test is that it can monitor the effectiveness of treatment to eradicate *H. pylori*, detecting almost immediately when the bacteria have been killed. With the blood test, *H. pylori* antibodies may still be present a year or more after the infection is gone.

Stool antigen test

This test checks for *H. pylori* in stool samples. It's useful in helping to diagnose *H. pylori* infection. It also may be useful in monitoring the success of treatment.

Treatment

An ulcer isn not something you should treat on your own, without a doctor's help. Over-the-counter antacids and acid blockers may relieve the gnawing pain, but the relief is always short-lived.

A combination of medications

With a doctor's help, you can find prompt relief from ulcer pain as well as a lifelong cure from the disease. Since most ulcers stem from *H. pylori* bacteria, doctors use a two-pronged approach:

- Kill the bacteria.
- Reduce the level of acid in the digestive system to relieve pain and encourage healing.

Accomplishing these two steps requires use of at least two, and sometimes three or four, of the following medications:

Antibiotics

Several combinations of antibiotics kill *H. pylori*. Most of the medications are equally effective, killing the bacteria nearly 90 percent of the time. However, for the treatment to work, it is essential that you follow your doctor's instructions precisely.

Antibiotics most commonly prescribed for treatment of *H. pylori* include amoxycillin, clarithromycin, metronidazole or tetracycline. Some pharmaceutical companies package a combination of two antibiotics together, with an acid suppressor or cytoprotective agent specifically for treatment of *H. pylori* infection. These combination treatments are sold under different names.

You'll need to take antibiotics for only 1 to 2 weeks, depending on the type and number of antibiotics your doctor prescribes.

Other medications prescribed in conjunction with antibiotics generally are taken for a longer period.

Acid blockers

Acid blockers — also called histamine (H-2) blockers — reduce the amount of hydrochloric acid released into the digestive tract to relieve ulcer pain and encourage healing. Normally, this acid is not damaging to the stomach and duodenum. But if a defect develops in the mucous layer that coats the digestive tract, hydrochloric acid can seep into the defect and produce an ulcer. Other ulcer-promoting factors, including use of nicotine, NSAIDs and alcohol, increase the risk of the defect turning into an ulcer.

Acid blockers work by keeping histamine from reaching histamine receptors. Histamine is a substance normally present in the body. When it reacts with histamine receptors, the receptors signal acid-secreting cells in the stomach to release hydrochloric acid.

Available by prescription or over the counter, acid blockers include the medications ranitidine, famotidine, and cimetidine.

Antacids

Your doctor may include an antacid in your drug regimen. An antacid may be taken in addition to an acid blocker or in place of one. Instead of reducing acid secretion, antacids neutralise existing stomach acid and can provide rapid pain relief.

Proton pump inhibitors

A more effective way to reduce stomach acid is to shut down the "pumps" within acid-secreting cells. Proton pump inhibitors reduce acid by blocking the action of these tiny pumps. They include the prescription medications omeprazole, lansoprazole, rabeprazole and esmaprazole. Another drug, pantoprozole, can be taken orally or administered intravenously in the hospital.

Proton pump inhibitors also appear to inhibit *H. pylori*. However, the drugs cost almost twice as much as acid blockers. Uncommon side effects include stomach pain, diarrhoea and headache.

Cytoprotective agents

These medications are designed to help protect the tissues that line the stomach and small intestine. They include the prescription medications sucralfate and misoprostol.

The drugs carry some side effects. Sucralfate may cause constipation. Misoprostol may cause diarrhoea and uterine bleeding. Pregnant women should not take Misoprostol because it can cause miscarriage.

Another cytoprotective agent is bismuth subsalicylate. In addition to protecting the lining of the stomach and intestines, bismuth preparations appear to inhibit H. pylori activity.

Measures you can take

Before the discovery of *H. pylori*, people with ulcers were often placed on a restricted diet and told to reduce the amount of stress in their lives. Now that food and stress have been eliminated as causes of ulcers, these factors no longer apply.

However, while an ulcer is healing, it is still advisable to watch what you eat and control stress. Acidic or spicy foods may increase ulcer pain. The same is true for stress. Stress slows digestion, allowing food and digestive acid to remain in your stomach and intestines for a longer period.

Your doctor also may suggest these steps:

- Don't smoke.
- Avoid alcohol.
- To relieve pain, take paracetamol instead of NSAIDs.

Most ulcers heal with treatment

With treatment, about 19 in 20 peptic ulcers disappear completely within a few months. However, the ulcer may recur if lifestyle changes are not made or if there is reinfection with *H. pylori*.

[This column is primarily intended to educate the reader about the basics, and the do's and don'ts in a medical situation, and not as a substitute for professional medical advice. Before starting any form of treatment, please consult your physician.]

Recent developments in science and technology

LHC creates mini Big Bangs by colliding lead ions

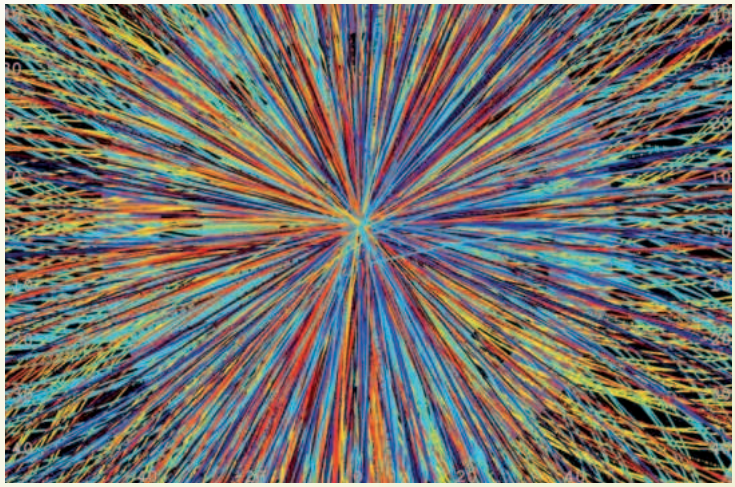
Scientists at the Large Hadron Collider (LHC) near Geneva, world's biggest atom smasher, smashed the first stable beams of lead ions on 8 November 2010, creating the first mini 'Big Bangs' and the highest temperatures and densities ever achieved in an experiment that mimicked conditions a millionth of a second after the birth of the universe. According to the researchers, the collision event took place in a safe, controlled environment generating incredibly hot and dense sub-atomic fireballs with temperatures of over 10 trillion degrees Celsius – a million times hotter than the centre of the Sun.

The lead-ion collisions took place at energy of 287 TeV (287 $\times 10^{12}$ eV) per beam. Each lead nucleus contains 82 protons, and the LHC accelerates each proton to energy of 3.5 TeV, thus resulting in energy of 287 TeV per beam, or a total collision energy of 574 TeV. The lead ion collisions were detected by a host of detectors including ALICE (A Large Ion Collider Experiment), ATLAS (A *T*oroidal *L*HC *A*pparatu*S*), and CMS (*C*ompact *M*uon *S*olenoid).

When two lead nuclei slam into each other at high enough energy, they form a fireball of hot, dense matter. The temperatures created in the fireball are so great that they turn the protons and neutrons into a dense soup of subatomic particles known as quark–gluon plasma (QGP), in which quarks and gluons roam freely. The QGP exists for only an instant before the fireball expands and cools to the point where quarks and gluons once again form composite particles.

One of the main scientific goals of the ALICE detector of the LHC is to characterise the quark–gluon plasma in an attempt to find out more about the nature of the strong force, one of the four fundamental forces of nature. Despite being responsible for generating 98% of the mass of atoms, the strong force is still the most poorly understood of the forces. For this purpose, ALICE was specifically designed to track large numbers of particles. It can detect up to 15,000 particles per event, which may be produced from the collisions between lead nuclei occurring in the centre of the detector.

The 8 November event marks the beginning of the main physics programme for the ALICE experiment, which has been designed specifically for heavy-ion collisions and is seeking to recreate the conditions that existed just 10^{-11} s after the Big Bang. At that time, the energy in the universe was so concentrated that protons and neutrons could not hold together – instead, space began to be filled with QGP.



One of the first lead-ion collisions in the Large Hadron Collider, as recorded by the ALICE detector. This was a high-multiplicity collision that produced thousands of particles, including muons. (Credit: CERN)

Earlier, in September 2010, the LHC had produced its first pair of Z bosons through proton collision, which were detected by the CMS. Creation of this first pair is considered an important step in LHC's hunt for the Higgs boson because the generation and analysis of many more such events could provide one of the key signatures of the elusive Higgs boson. The CMS experiment uses a general-purpose detector to investigate a wide range of physics, including the search for the Higgs boson, extra dimensions, and particles that could make up dark matter.

Inside view of the Large Hadron Collider

The LHC was built to help scientists answer key unresolved questions in particle physics. According to some scientists, the unprecedented energy it achieves may even reveal some unexpected results that no one has ever thought of. For the past few decades, physicists have been able to describe with increasing detail the fundamental particles that make up the universe and the interactions between them. This understanding is encapsulated in the Standard Model of particle physics, but it contains gaps and cannot tell us the whole story. To fill in the missing knowledge requires experimental data, and the next big step to achieving this is with LHC.

Physicists believe that the universe was filled with QGP millionths of a second after the Big Bang, until it expanded and cooled enough for the very first composite particles to form. This process is mirrored at very small scales in heavy-ion collisions, allowing scientists to study in the laboratory one of the early stages of the universe's evolution. By creating millions of QGPs over the next month, scientists will learn more about how the basic building blocks of matter – quarks and gluons – come together to form particles, which in turn form all the matter in the universe.

The LHC will be colliding lead ions until 6 December. The accelerator will then be shut down for two months for maintenance, and will start up again in February 2011 with proton beams.

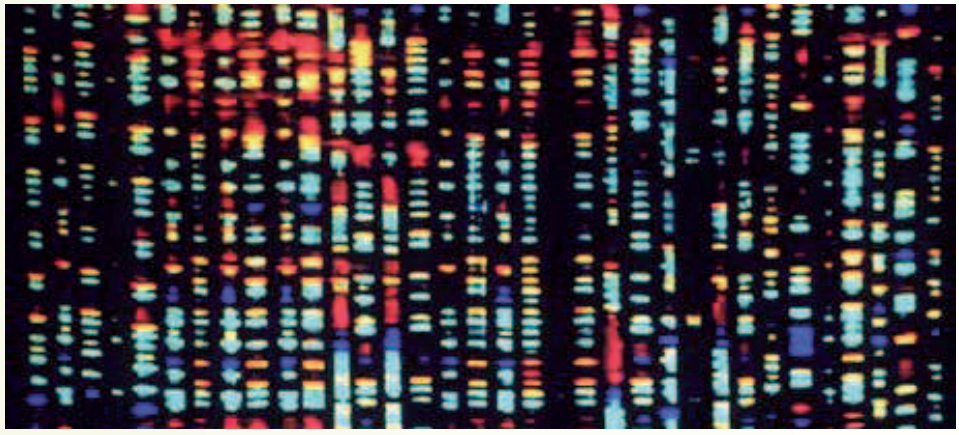
First results from the 1000 Genome Project published

The most comprehensive map of the small genetic differences between individuals, called variations, were published in the journal *Nature* (28 October 2010) as part of the 1000 Genomes Project – an international public-private consortium. The map contains an estimated 95 percent of the genetic variation of any person on Earth. The map was produced by the researchers using next-generation DNA sequencing technologies to systematically characterise human genetic variation in 180 people in three pilot studies.

Launched in January 2008, the 1000 Genomes Project is an international research effort to produce an extensive catalogue of human genetic variation that will support future medical research studies. Under the project it is planned to sequence the genomes of at least one thousand anonymous participants from a number of different ethnic groups within three years, using newly developed technologies which are faster and less expensive. The *Nature* report brings out the findings of the pilot phase. The full scale-up from the pilots is already under way, with data collected from more than 1,000 people.

Small genetic differences between individuals help explain why some people have a higher risk than others for developing illnesses such as diabetes or cancer. Genetic variation between people refers to differences in the order of the chemical units – called bases (A, T, C, G) – that make up DNA in the human genome. These differences can be as small as a single base being replaced by a different one – which is called a 'single nucleotide polymorphism' (SNP) – or can be as large as whole sections of a chromosome being duplicated or relocated to another place in the genome. Some of these variations are common in the population and some are rare.

One of the primary objectives of the 1000 Genome Project is to understand populations. For instance, by comparing lots of genomes researchers will be able to identify points at which one genome differs from the next. For projects examining how populations commonly differ, sequencing a large number of individuals at relatively low accuracy or 'depth of coverage' is enough. Researchers can create a map of all types of genetic variation by comparing the base sequences in the genome of many individuals to one another and by comparing one population to other populations.



A digital representation of the human genome. Each colour represents one the four bases of DNA.

Measurement of human DNA variation is an essential prerequisite for carrying out human genetics research. The 1000 Genomes Project represents a step towards a complete description of human DNA polymorphism (the presence of genetic variation within a population, upon which natural selection can operate). The project aims at providing a deep characterisation of human genome sequence variation as a foundation for investigating the relationship between genotype and phenotype. The larger data set that will be available from the full 1000 Genomes Project will provide a comprehensive public resource that can help researchers intending to study all types of genetic variation that might cause human disease. Already, these data have been used in studies of the genetic basis for disease.

Till now, populations with European, West African and East Asian ancestry have been studied. Using the newest technologies for sequencing DNA, the project's nine centres sequenced the whole genome of 179 people and the protein-coding genes of 697 people. Each region was sequenced several times, so that more than 4.5 million million (45×10^{11}) bases of DNA sequence were collected. The work was carried out by a consortium involving academic centres on multiple continents and technology companies that developed the sequencing equipment.

Under the 1000 Genomes Project about 900 genomes have been sequenced so far. Although far from comprehensive, the latest tally indicates that at least 2,700 human genomes will have been completed by the end of November 2010, and that the total will rise to more than 30,000 by the end of 2011.

Global warming in the ancient past

Despite irrefutable evidence of increase in levels of carbon dioxide being the principal contributor to global warming in recent years, there are many who consider such a link to be unreal and exaggerated. Now a study by a team led by Peter K. Bijl of Utrecht University, working with colleagues at the NIOZ Royal Netherlands Institute for Sea Research, and the University of Southampton, UK have come out with evidence of global warming caused by high atmospheric carbon dioxide levels in the distant past. Their study showed that variations in atmosphere carbon dioxide around 40 million years ago were tightly coupled to changes in global temperature (*Science*, 5 November 2010).

The Eocene Epoch, which lasted from about 56 to 34 million years ago, is a major division of the geologic timescale. It has been known that there was a warming period about 40 million years ago, during the Middle Eocene Climatic Optimum (MECO), one of the hottest intervals in Earth's climate history, when deep sea temperatures rose by about 4°C. Although it was speculated that this rise in temperature was associated with relatively high atmospheric carbon dioxide levels, scientists were previously unable to demonstrate a direct link between variations in atmospheric carbon dioxide and short-term changes in global temperature.

For the present study the researchers analysed fossilised algae to reconstruct ancient climate. Algae use photosynthesis, converting carbon dioxide and water into the organic molecules required for growth using sunlight. Carbon has different isotopes

Destruction of carbonate rocks as the Himalayas formed might have contributed to a dramatic rise in atmospheric carbon dioxide 40 million years ago.

which are incorporated into the organic molecules produced by algae depending on the environmental conditions under which they grow. Ancient climate can therefore be reconstructed by analysing the carbon isotope ratios of molecules preserved in fossilised algae.

The researchers used fossilised algae preserved in sediment cores extracted from the seafloor near Tasmania, Australia, by the Ocean Drilling Program. They used the available information on the past marine ecosystem, derived from studying changes in the abundance of different groups of fossil plankton, to refine their estimates of carbon dioxide levels. Their analyses indicated that carbon dioxide levels must have at least doubled over a period of around 400,000 years. In conjunction with these findings, data on sea surface temperature available from other sources show that the climate warmed by between 4 and 6°C over the same period. From the analysis the researchers found a close correspondence between carbon dioxide levels and sea surface temperature over the whole period, suggesting that increased amounts of carbon dioxide in the atmosphere played a major role in global warming 40 million years ago.

The researchers point out that the large increase in atmospheric carbon dioxide indicated by their analysis would have required a natural carbon source capable of injecting vast amounts of carbon into the atmosphere. One possible cause of the rapid increase in atmospheric carbon dioxide levels around 40 million years ago could be the release of carbon dioxide caused by destruction of carbonate rocks with the rise of the Himalayas, which occurred around the same period, as suggested in another paper in the same issue of *Science* by Paul N. Pearson of Cardiff University. Be that as it may, the recent findings do corroborate what climatologists have been suggesting for many years now – that increase in levels of atmospheric carbon dioxide due to human activity is indeed the real cause of the current global warming.

Bacteria influence evolution

According to Charles Darwin, evolution is a random process that proceeds through natural selection in which only the fittest organisms survive and prevail over those who are unfit. But a recent study by a team of researcher of Tel Aviv University, Israel, shows that some organisms may be capable of influencing the evolutionary process. The researchers, led by microbiologist Gil Sharon raised some fruit flies (*Drosophila melanogaster*) on molasses and others on starch. They expected – on the basis of previous studies – that the flies would mate preferentially with partners raised on the same diet, and the flies did.

Bacteria living on the fruit fly, Drosophila melanogaster, *influences the fly's mating preferences.*

However, the researchers did not have any idea why the flies showed a preference for mates that shared the same diet.

It was later discovered that a change in diet acted on symbiotic bacteria living on the flies and influences their mating preference, rather than acting directly on the flies themselves. Probably, bacteria that live on the fruit fly can affect their host's choice of mate by altering the fly's pheromones. According to the researchers, the change in mate choice could in turn lead to the evolution of new fly species – suggesting that bacteria can indirectly change the species of their hosts (*Proceedings of National Academy of Sciences*, 1 November 2010 | doi:10.1073/pnas.1009906107). This idea is consistent with the 'hologenome theory' of evolution, first proposed by two members of the research team, Eugene Rosenberg and his wife, fellow evolutionary biologist Ilana Zilber-Rosenberg, in 2008, which emphasises the role of microorganisms in the evolution of animals and plants. In the study the fruit flies were found to develop a mating preference just a single generation after they were introduced to a new diet and the effect was seen to last for 37 generations.

To confirm that it was the bacteria on them that were influencing their mating behaviour and not the direct response of flies to their diet, the researchers treated the flies with antibiotics, wiping out the bacteria that live on them. They then tested the flies again and found that they mated randomly and did not show any preference for same-diet partners. This indicated that the bacteria were indeed influencing the flies' mate choice.

By looking at genetic fingerprints, the researchers identified *Lactobacillus plantarum* as the bacterial species responsible. In flies fed on a diet of starch, *L. plantarum* made up 26% of their symbiotic bacteria, compared with just 3% on molasses-fed flies. To confirm that *L. plantarum* was indeed responsible, antibiotic-treated flies were re-infected with the bacterium, and seen to return to preferential mating behaviour.

The team also examined fly pheromones – chemicals that affect the behaviour of other members of the same species. Although the results are not yet conclusive, the researchers found that the starch-fed flies had altered levels of some pheromones known to be involved in mating behaviour.

Biman Basu ■

Your opinion

Dream 2047 has been inviting your opinion on a specific topic every month. The reader sending the best comments will receive a popular science book published by VP. Selected comments received will also be published in *Dream 2047*. The comments should be limited to 400 words.

This month's topic:

"Will it be possible to control global warming in the next 50 years?"

Response should contain full name; postal address with pincode and email ID, if any; and should be accompanied by a recent passport size photograph. Response may be sent by email (opinion@vigyanprasar.gov.in) or by post to the address given below. If sent by post, "Response: *Dream 2047* January 2011" should be clearly written on the envelope.

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Winners of "Your Opinion" contest for October 2010

Topic: "Can mosquito-borne diseases like malaria and dengue be eradicated, given the public apathy to sanitation and cleanliness?"

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The Central and State governments have launched many a projects for the eradication of mosquito-borne diseases like malaria and dengue. NGOs and voluntary organisation are spending a lot of money on it. A survey on malaria deaths shows that the average death toll by these diseases is still alarmingly high in India in spite of govt. initiatives. The main reason is the fact that a majority of the population of the country resides in rural areas and slums with least awareness of sanitation and cleanliness. Lack of consciousness due to illiteracy is one major reason. It is not money but the mindset of the public that counts.

In my opinion these pandemic diseases can be eradicated with a concerted effort in creating public awareness on cleanliness supplemented by Government's health programmes, improved management information system (MIS), and effective public distribution system (PDS) in remote and rural areas, ensuring access to personal and community sanitary services.

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India lacks sanitation facilities. If one moves to towns it is common scene that the sewage system is choked and the stagnant water promotes breeding of mosquito at a rapid rate leading to diseases like malaria and dengue. To eradicate mosquito-borne diseases everyone has to contribute his/her mite. Mass communication is the best way to educate the people; we can have rallies to spread awareness about the how these diseases are spread. In my opinion mosquito-borne diseases can be eradicated with the help of active participation of people in spreading awareness.

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We all know that cleanliness is next to godliness. To keep ourselves disease-free, it is necessary to keep cleanliness. To maintain cleanliness is not only the responsibility of government but also the people in society. For the government to maintain cleanliness there should be public interest. Then only can we eradicate disease. If public interest is not there, we cannot eradicate malaria and dengue. These diseases can be eradicated only if the breeding of mosquitoes is prevented by active public support, which can be done by better sanitation and prevention of water stagnation anywhere.

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